COMPARATIVE EVALUATION OF PRESSURE GENERATED ON A MAXILLARY MODEL BY DIFFERENT IMPRESSION MATERIALS USING CUSTOM TRAYS FABRICATED WITH DIFFERENT THICKNESS OF WAX SPACER – AN IN VITRO STUDY

Dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

CHENNAI

In partial fulfillment

For the requirements for the degree of

MASTER OF DENTAL SURGERY

BRANCH-I

PROSTHODONTICS AND CROWN & BRIDGE

MAY-2019

CERTIFICATE-I

This is to certify that the dissertation titled "**COMPARATIVE EVALUATION OF PRESSURE GENERATED ON A MAXILLARY MODEL BY DIFFERENT IMPRESSION MATERIALS USING CUSTOM TRAYS FABRICATED WITH DIFFERENT THICKNESS OF WAX SPACER – AN IN VITRO STUDY**" is a bonafide work done by **Dr.K.A.Biju**, postgraduate student, during the course of the study for the degree of "Master of Dental Surgery" in department of, **PROSTHODONTICS AND CROWN & BRIDGE**, KSR Institute of Dental Science and Research, Tiruchengode during the period of 2016-2019, under our supervision and guidance.

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*****

Your dissertational study titled "COMPARATIVE EVALUATION OF PRESSURE GENERATED ON A MAXILLARY MODEL BY DIFFERENT IMPRESSION MATERIALS USING CUSTOM TRAYS FABRICATED WITH DIFFERENT THICKNESS OF WAX SPACER – AN IN VITRO STUDY" presented before the ethical committee on 16th Dec. 2016 has been discussed by the committee members and has been approved.

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DURATION OF COURSE	3 years
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I hereby declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Principal, K.S.R Institute of Dental Science and Research, Tiruchengode. In addition, I declare that no part of this work will be published either in print or electronic without the guide who has been actively involved in this dissertation. The author has the rights reserved for publishing the work solely with prior permission of the Principal, K.S.R Institute of Dental Science and Research, Tiruchengode.

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CERTIFICATE- II

This is to certify that this dissertation work titled **"COMPARATIVE EVALUATION OF PRESSURE GENERATED ON A MAXILLARY MODEL BY DIFFERENT IMPRESSION MATERIALS USING CUSTOM TRAYS FABRICATED WITH DIFFERENT THICKNESS OF WAX SPACER – AN IN VITRO STUDY"** of the candidate **Dr.K.A.Biju** with registration number **241611251** for the award of **Master of Dental Surgery** in the branch of **Prosthodontics and Crown & Bridge**. I personally verified the urkund.com website for the purpose of plagiarism check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **9** percentage of plagiarism in the dissertation.

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VPS	Vinyl polysiloxane
PE	Polyether
PMMA	Polymethyl methacrylate
FSR	Force sensitive resistor
Mpa	Mega pascal
ANOVA	Analysis of variance
p	Probability
SD	Standard deviation
df	Degrees of freedom
sig	Significance level
Fig	Figure
no	Number
et al.,	And others

Impression making in complete denture Prosthodontics has transformed from the carving of wooden and ivory blocks (that accommodated the intra oral contours), to easier comfortable and more sophisticated methods in modern practice. Prior to 1600s the complete denture replacements were not made, due to the lack of understanding, of retention. The basic principles of complete denture impression making were introduced in the middle of the 19th century, such as the concepts of maximum extension of denture-bearing area, atmospheric pressure, equal distribution of pressure, and adaptation of the denture to the bearing tissues.[1]

The objective of impression making is to construct dentures with maximum retention and stability without causing damage to the supporting structures.[2] Impression is basically an interaction between the impression material and the tissues. There are different theories in literature for recording the edentulous ridges with an impression. The ideas that have been proposed over the years in relation to pressure applied are:

- No Pressure / Mucostatic theory
- Pressure / Mucocompressive theory
- Selective Pressure theory

Mucostatic theory: Harry .L. Page in 1946, stated that all the soft tissues are chiefly fluid and 80% of the tissues are composed of water. According to Pascal's Law, "any pressure applied to a confined fluid is transmitted equally in all directions and undiminished". All these principles advocated that the Interfacial tension was the only important retentive mechanism in complete denture.[3]

According to the principle of Mucostatics, the impression material should record all the details of the mucosa without any distortion, so that a completed denture would fit into all minute elevations and depressions.

Mucocompressive theory: This technique was initiated by the Greene Brothers. They were said to be the first to teach the closed mouth all modelling plastic technique called the Greene Brothers all compound impression. The dentures fabricated by this technique were in a continuous state of compression, creating poor vascularity leading to resorption of the underlying bone. The opponents proposed that a continuous functional state was not necessary in an artificial denture because it remained only for a few minutes in a day.[3]

Selective pressure theory: This technique was advocated by Boucher in 1950. It combined the principles of both pressure and minimal pressure techniques. The principle behind this impression technique was that the mucosa over the ridge area was best suitable to withstand the pressure, whereas the area covering the midline was thin and contained very little sub mucosal tissue. Hence, an equilibrium was created between the resilient and non resilient tissues.[3]

Primary stress bearing areas of the maxilla are the crest of the residual alveolar ridge and the horizontal slopes of the palatine bone and the secondary stress bearing areas are the Rugae. Areas requiring relief are the incisive papilla, midpalatine suture and tori areas in the maxilla. The non-stress bearing areas are to be recorded with least amount of pressure, whereas selective pressure could be applied in certain areas of the maxilla.[3]

In edentulous patients, alveolar ridge mucosa is of variable thickness and mobility in different areas. Due to the morphological differences in the hard and the soft tissues, the pressure applied on the oral mucosa must be controlled or limited. Cortical bone has the capability to bear functional load, whereas the residual alveolar ridges are susceptible to resorption and cannot tolerate these loads.

Similarly, a keratinized, firm masticatory mucosa can resist the functional loads whereas the non-keratinized mucosa and submucosa with lesser thickness cannot tolerate such loads. Incisive papilla and mid-palatine raphe regions have low stress bearing ability and the loads applied to these regions must be minimal to minimize trauma.[4]

The consistency of impression material also affects the pressure applied to the mucosal tissue beneath the denture base. Differences in properties of impression materials enable the use of different methods to obtain better results. Appropriate selection of impression material by a clinician should be entirely based on the oral status, function and type of tissues, and mainly the handling skill of the operator. Other factors that govern the impression pressure include the viscoelastic characteristics of the impression material, the tray seating speed, the tray holding pressure, and the contour of the tray.[5]

During rehabilitation of edentulous patients the mucosal tissues have to be recorded with minimal distortion, and to achieve that, an appropriate impression technique and a suitable impression material which has an optimal flow to obtain favourable retention and stability of denture has to be used. Among the different impression theory for complete dentures, Selective pressure technique has been widely accepted in the literature. Duncan et al., states that the Selective pressure impression theory provides the clinician with a method for improving the palatal adaptation of maxillary complete dentures.[6] Selective pressure could be enhanced by altering the spacer thickness, the spacer design and the materials used for making the impression. But the spacer deign varies from one text to the other and there is no definitive explanation for the thickness of the spacer to be used which leads to changes in the pressure formed within a custom tray.[3]

Hence, the purpose of this study was to know whether the spacer thickness and the materials used for impression making with a custom tray of similar tray and spacer design(following the selective pressure theory), had any relation to the quantum of pressure exerted on the denture foundation area, during impression making. The study also evaluated if there was any significant change in pressure exerted on the denture foundation area, when providing escape holes in the custom trays.

Following the Mucostatic theory, the denture foundation area will be recorded in a static/ minimal compression form, resulting in a denture with compromised retention, stability and esthetics. Whereas, when following the Mucocompressive theory, there will be a constant pressure exerted on the denture foundation area, consequently leading to resorption of the underlying bone.

Thereby, the Selective pressure theory has been recommended for making impressions of edentulous residual ridges. Although various methods for making impressions have been reported, a definitive procedure has not been clearly elucidated.

This study, will evaluate changes in impression pressure produced by different thickness of relief spacer and by different impression materials along with variable escape holes in the impression tray for making an impression of a simulated maxillary edentulous model.

AIM OF THE STUDY:

This study was conducted with the following aims:

- To determine the amount of pressure exerted on different areas of a maxillary analog during secondary impression procedures, when using a similar tray and spacer design, with different spacer thicknesses.
- To determine the amount of pressure exerted on different areas of a maxillary analog during secondary impression procedures, when using two different impression materials.
- And also to evaluate whether the escape holes play a role in changing the pressure exerted during secondary impression.

OBJECTIVE OF THE STUDY:

Primary objective:

- To compare the pressure exerted on different areas of a maxillary analog during secondary impression procedure, using Vinyl polysiloxane material in trays with similar design, with single and double spacer thicknesses.
- To compare the pressure exerted on different areas of a maxillary analog during secondary impression procedure, using Polyether material in trays with similar design, with single and double spacer thicknesses.
- To evaluate and compare the amount of difference in the pressure exerted by both the impression materials in trays with similar design, with single and double spacer thicknesses.

Secondary objective:

- To evaluate the significance of vent holes in the difference of the pressure exerted during secondary impression procedure, in trays with similar tray design, for both the spacer thicknesses of VPS group and Polyether group.

- There is no significant difference between the amount of pressure exerted on different areas of a maxillary analog during secondary impression procedures, using Vinyl polysiloxane material in trays with similar design, with single and double spacer thicknesses.
- There is no significant difference between the amount of pressure exerted on different areas of a maxillary analog during secondary impression procedures, when using Polyether material in trays with similar design, with single and double spacer thicknesses.
- There is no significant difference between the amount of pressure exerted by both the impression materials in trays with similar design, with single and double spacer thicknesses.
- There is no significant difference in the amount of pressure exerted in the region of escape hole on the crest region, during secondary impression procedure, in trays with similar design, with single and double spacer thicknesses, when using either of the impression materials.

Stansbury CJ (1925)[7] A negative factor with regards to both stability and retention was pressure along the median line of the hard palate, which may act as a fulcrum when the tissues on the alveolar ridge are being compressed during mastication. Another negative factor would be the elasticity of the pad of tissues overlying the anterior palatine artery and its main branches, if the technique employed had resulted in pressure over the areas. So from the article, it was concluded that if an impression was taken at one time, three distinct areas, each with its own individual condition existed. (1) the area with the post-dam modelling compound under section or negative pressure (2) the area of the ridges under heavy pressure and (3) the area without the ridge, taken under a variable pressure increasing from ridge crest to peripheral seal. As a distinctive method, base upon logic and confirmed by clinical use, this procedure called the “negative pressure method of impression” making will do away with many impression problems.

Addison PI (1944)[8] There are scientific theories for the construction of full lower dentures and a more logical approach to the handling of any bone based soft tissues intended to support prosthetic appliances. Atrophy of the ridges could be completely discouraged by the perfection of fit and the overall evenness of pressure and counter pressure the gentle intermittent pressure during function and non-function can maintain the ridge in prime condition, free from any evidence of chronic irritation.

Boucher CO (1951) [9] Even a casual examination of the current dental literature will indicate the confusion that exists in the problem of impressions for complete dentures. This article explains about the variations of methods, materials, objectives and interpretation of the related factors associated with impression procedures& thereby providing a clear clinical view in selection of the material and the technique that could be used for impression making for complete denture fabrication.

Roberts AL (1951)[10] The impression making is the most important and second step in full denture constructions. This article emphasizes about the three specifications for an adequate full impression and they are as follows: 1) the form of the denture foundation, i.e., the oral tissues must resist the stress of occlusion and it should be recorded without distortion. 2) The outline of the basal seat i.e., the entire area has to be covered by the denture, and should be recorded as it is determined by functional movements of border tissues. 3) Relief and dams should be placed at operator's direction in stratergic areas. In simple, the impression is the result of the form of foundation tissue, border tissue plus what the operator does to it. Truly, the denture impressions are made not taken.

Porter CG (1953)[11] The word "mucostatics" was used to designate a theory of impression making and denture base constructions, in which the ridge tissue was maintained in an undisplaced, undistorted or passive form. Mr. Henry Page was credited with the originality of the "mucostatic principle". Mr. Page's attempt to prove by Pascal's law that the soft tissues of high water content was confined and immobilized under a "mucostatic base" and "will immovably support just as much load as hard issues",- will not bear close scrutiny so a metal denture base was recommended to ensure intimate contact with the supporting tissues for mucostatic technique.

Buckley GA (1955)[12] Most of the impression materials and impression methods can be used to the best advantage if they are applied to patients for whom they are indicated. In this article, they have discussed regarding the choice of impression techniques and impression materials based upon the clinical criteria such as; soft tissue condition, ridge shape, palate shape, mucobuccal fold and the size of the denture bearing area.

Tilton GE (1956)[13] The pressure applied in impression making must be equally balanced throughout the entire area of the impression. In this article, a technique for making impressions for complete dentures with a minimum pressure was described by removing the impression material in the relief area i.e., the incisive papilla to the mid palatine region and it was loaded with very soft plaster and held under extreme pressure until the plaster set. This soft plaster worked very well and the resulting denture was comfortable to the patient.

Lambrecht JR, Kydd WL (1962)[14] Maintenance of the supporting tissues in a physiologic condition was a prime requisite when constructing an oral prosthesis. The change in the tissue displacement that occurs cause an unequal distribution of functional forces. The purpose of this study had two objectives: 1) to formulate a pattern of functional base deformation for maxillary dentures, 2) after the deformation pattern was established, its reproducibility was evaluated.

Woelfel JB (1962)[15] The purpose of this study was to determine how accurately or inaccurately a dentist could reproduce the surface details and tissue contours of an upper edentulous arch with one impression tray and five different corrective wash impression materials. From this study it was concluded that the placement of spacer and escape holes in an impression tray are far more important factors in producing an excellent final impression than is the choice of a corrective wash material. The author also reinforced that the tray should be modified differently to meet the requirements of the specific type of wash materials used.

Frank RP (1969)[16] The objective of this investigation was to find a reliable method to measure the pressures exerted upon the maxillary edentulous residual ridge and the palate during impression procedures. Tray modifications selected for study were the presence or absence of relief space and / or escape holes. The impression materials investigated were zinc oxide and eugenol paste, a light-bodied Thiokol rubber and an irreversible hydrocolloid. From the study, it was conclude that the impression pressures can be controlled by the tray design and the material selection.

Collet HA (1970)[2] The objective of impression making was to construct dentures whose bases should have maximum retention and stability without causing damage to the supporting structures. The selection of the procedure must be determined by the knowledge and belief that best will be accomplished for the one specific patient. The purpose of this article was to examine some of the technical aspects of final impression for complete dentures and to explain what might have to be accomplished for the patients with them.

Nedelman C, Gamer S, Bernick S (1970)[17] The present investigation, which used histochemical and enzyme –histochemical reactions, was undertaken to determine the changes in the residual alveolar ridge mucosa of both edentulous and denture wearing individuals. Biopsies were taken from the ridge mucosa if complete denture and non-denture wearers sections were stained for esterase acid and alkaline phosphatase activity and for glycogen in the epithelial layer, a thickened stratum corneum and a heavy inflammatory infiltrate in the underlying submucosa. On the other hand, the ridge mucosa of denture wearers consisted of a thin stratum corneum, loss of a demonstrable glycogen absence of inflammatory cells in the submucosa with thick fibre bundles. Denture wearers also exhibited decreased enzymatic activity for all enzymes studied.

Rihani A (1981)[18] This study was concerned with the pressure in specific areas of the palate, residual ridges and buccal borders during impression making. A method of measuring the relative pressures in different regions of the upper denture bearing area was devised .these pressures were registered with the use of manometers. The results indicated that the main pressure regions during impression making near the center of the palate and those pressures diminished towards the buccal borders.

Zinner ID, Sherman H (1981)[1] This study documents the frequency and historical development of knowledge associated with scientific advancement from 1845 to 1964 in biology, psychology, material science and the clinical sciences as they related to impression procedures in complete denture prosthodontics. This article also emphasize on the importance of an in - depth review of impression making which lies in the assessment of the historical value of all factors.

Arikawa H et al., (1982)[19] The purpose of this study investigation was to develop a testing instrument for determination of working and setting times of elastomeric impression materials. The apparatus used in this study was a modification of the oscillating rheometer designed by bovis this device was found to be a suitable as a testing instrument for determining the working and setting time of elastomeric impression materials. Futhermore, it was also found that this instrument could be used for investigating rheological properties during setting.

Pagniano RP, Schied RC, Clowson RL, et al (1982)[20] The purpose of this study was to evaluate the linear dimensional change of four commercial cold curing acrylic resin custom tray materials. A continuous 24 hour measurement of the materials was done to determine the period where most change occurred. Another aspect of the study measured the dimensional changes of the acrylic resin materials after the specimens were placed in boiling water. This study showed that more the period of time a cold curing acrylic resin tray was stored prior to use, the more stable it became.

Appelbaum EM, Mehra RV (1984)[21] To border mold a custom tray with modeling compound and then to make a final impression with a free –flowing impression material was an adequate but time-consuming procedure, particularly for dental students with the advent of elastic impression materials, good results can be obtained. From this study, it was concluded that polyvinyl siloxane putty and light-body impression material are well suited for making complete denture impressions, obviously with less expenditure of time as well as discomfort and inconvenience to the patient, especially in the hands of an inexperienced operator.

De Araujo PA, Jorgensen KD, Finger W (1985)[22] The viscoelastic properties of elastomeric impression materials are commonly recorded by methods similar to those of the American dental association specification number; 19. This study has recorded the relationship between induced and permanent tensile deformation of elastomeric dental impression materials during and after setting. From the study, it was concluded that the elastic recovery time was recorded for set materials, after the deformation was induced; that is 10 minutes after mixing the silicone or 15 minutes after mixing the polyether and polysulfide materials. This method accurately recorded the viscoelastic properties of impression materials.

el-Khodary NM, Shaaban NA, Abdel-Hakim AM (1985)[23] The oral mucosa of edentulous patients were subjected to mechanical forces that vary in nature. This investigation reports the effects on the histopathologic and the enzyme histologic responses of the oral mucosa of complete dentures made with three impression techniques- minimal (mucostatic) pressure, maximal (biting) pressure or functional pressure. From the study it was concluded that dentures made with functional impression technique appeared to be most protective to the underlying supporting mucosa, while those made with the biting pressure technique may affect the tissues unfavorably.

Goldfogel M, Harvey WL, Winter D (1985)[24] The purpose of this study was to examine some newer improved autopolymerizing acrylic resin tray materials twelve commercially available autopolymerizing acrylic resin tray materials were measured for linear dimensional changes over a 24 hr period, when standard laboratory bench cure methods of fabrication were used. From this study it was concluded that three of 12 tray materials were found to expand slightly during the first few hours, which had the effect of reducing the net shrinkage. Therefore autopolymerizing acrylic resin tray materials should not be used for an impression on the same day that they are made, unless the tray is boiled in a pressure pot.

Klein IE, Broner AS (1985)[25] A secondary impression for a complete denture should be made without distortion of the basal seat or peripheral (border) tissues. The modified basal seat loading impression technique attempts to combine the best features of the tissue loading concepts and the mucostatic or non pressure registration technique of the basal seat. The technique described in this article was based on this concept.

Chee WW, Donovan TE (1992)[26] The popularity of PVS is understandable due to its combination of excellent physical properties, handling characteristics and unlimited dimensional stability. This article gas reviewed the property of PVS and given guidelines for techniques that results in optimum performance in clinical situations.

Smith PW, Richmond R, McCord JF (1999)[27] This article is a survey done in UK regarding the design and various materials used in the fabrication of special tray in prosthodontics. This survey highlights several key factors related to the use of special trays based on the different materials used for fabrication of special trays and based on the difference in the tray design depending upon the clinical situation.

McCord JF, Grant AA (2000)[28] This article explains about the clinical and technical aspects of conventional impression making and the materials for the conventional procedures and their significance in regards to the clinical situations. In addition, examples of selective pressure impression techniques and functional techniques are presented in this article.

Masri R et al., (2002)[29] The purpose of this study was to measure in vitro, the pressure exerted under a maxillary edentulous impression using 3 commonly used impression materials and 4 impression tray configuration. The results showed that there was a significant difference in the pressure produced using different impression materials. From the study it was concluded that all the impression materials produced pressure during maxillary edentulous impression making, tray modification was not important in changing the amount of pressure produced. The impression materials used had more effect on the pressure produced during impression making on a simulated oral analog.

Rignon-Bret C, Dupuis R, Gaudy JF (2002)[30] This study was a new 3-dimensional measuring system to analyze and compare 2 complete denture reline impression techniques. Within the limitations of the in vivo study, the displacement of the tissue/ denture base interface was essentially equivalent with the use of an occluding and a digital mandibular impression technique.

Nishigawa et al., (2003)[31] The dynamics of the impression flow at seating of the impression tray has not been examined, as it cannot be viewed directly. But in this study, the dynamics of the impression flow whilst seating the impression tray was inspected visually by using a transparent tray. From the study it was concluded that the relief of the tray could decrease the flow speed at the relief area and escape hole could change the direction of the flow towards the hole. To obtain the static impression of the movable tissue like flabby tissue in the maxilla, relief should be prepared just above the tissues, and escape hole should be prepared to minimize the flow at the tissue area.

Petropoulos VC, Rashedi B (2003)[32] In 2001, a survey of U.S dental schools was conducted to determine which concepts techniques and materials are currently prevalent in the teaching of final impression procedures for complete dentures in the predoctoral clinical curriculum. A questionnaire study in survey comprised 11 multiple-choice questions and all the responses were taken into count for the survey. From the study, the questions eliciting the most varied responses were related to (1) materials used for the final impression (2)The amount of wax relief used for the custom tray and (3)impression philosophy taught.

Duncan JP, Raghavendra S, Taylor TD (2004)[6] There are several definitive impression techniques for recording the edentulous maxilla. Those may be categorised as functional, non pressure and selective pressure impressions. The objective of this article is to describe a selective pressure impression technique that was intended to improve adaptation of the maxillary denture base by compensating for the polymerization shrinkage of acrylic resin. By displacing the tissues of the palate and effectively creating a deeper vault on the definitive cast, the technique compensates for the shrinkage of the PMMA.

Komiyama et al., (2004)[33] This in vitro study evaluated changes in the impression pressure produced by different types of relief space and escape holes in impression tray for making an impression of a simulated maxillary edentulous arch. In this study silicone impression material (exodenture) and a maxillary acrylic cast were used. One was embedded at the mid- palatine suture region and the other one in left first molar area on the edentulous ridge. Three types of tray relief and four types of escape holes were taken as variables for the study. It was concluded that for making an impression of an edentulous maxilla the data suggested that a tray with an escape hole of 1 mm or larger or a 1.40 mm spacer thickness of base plate wax be used in selectively reduce palatal impression pressure when making an impression of an edentulous maxilla.

Devan MM (2005)[34] The author stated that "there would not be a problem in impression making if we are taking impression of casts". The problem is due to the presence of displaceable tissues in the mouth that varies in thickness, rigidity and degree of disaplacability depending on the direction of forces applied to it. So, he concludes that a dentist must literally make the impression rather than taking it.

Al-Ahmad A, Masri R, Driscoll CF, von Fraunhofer J, Romberg E (2006)[35]The purpose of the study was to measure the pressure exerted under a simulated mandibular edentulous impression at different locations using commonly used impression materials and four impression tray configuration. Three pressure transducers were embedded in the oral analog. From the study it was concluded that, all the impression materials used in the study produced pressure during simulated mandibular edentulous impression making. For making mandibular edentulous impressions, low-viscosity impression materials – light body polysulfide and light body vinyl polysiloxane were recommended. Tray modification was not important in changing the amount of pressure produced for the low-viscosity impression materials.

Shetty S, Nag PVR, Shenoy KK (2007)[36] An impression in complete denture is the first step in the fabrication of the complete denture prosthesis. Various theories have been proposed by different authors as to how to achieve an optimum impression in different trays. This article reviews the various ways of achieving selective pressure as seen by different author and also includes a custom tray design to achieve selective pressure, which is based on the newer concepts of the stress bearing and relieving areas in the maxillary edentulous impression procedures.

Singla S (2007)[37] Impression techniques seems to be based upon various philosophies and personal preferences and the clinicians in an effort to choose between the alternatives. This review article is an attempt to focus our attention on theories presented in relation to one particular criterion. Ideas presented over the years in relation to pressure applied, it reserves a place for individual practitioner's judgement in the application of literature to clinical problems. It seems to inform clinical decision and not to impose them.

Hyde TP, Craddock HL, Brunton PA (2008)[38] Oral mucosa can distort under impressions. To reduce or control mucosal distortion, modern impression techniques aim to reduce or control the impression pressure. If changing seating velocity significantly changes pressure, then this effect should be considered for clinical impressions of mucosa. From the study, it was concluded that changing the seating velocity of seating had a significant effect on the peak pressure produced during stimulated impressions. A faster velocity of compression resulted in a significantly higher pressure.

Hyde TP, Craddock HL, Blance A, Brunton PA (2010)[39] This study investigated the effectiveness of a selective pressure impression against the traditional clinical method of redistributing pressure and the control denture from a relatively mucostatic standard impression. From the study it was concluded that the selective pressure technique provides a good outcome of results for the clinical procedures.

Rao S, Chowdhary R, Mahoorkar S (2010)[41] This review article documents the historical development of knowledge associated with scientific advancements from 1845 to 2009. It relates to impression procedures in conventional complete denture prosthesis. This article has also explained about a wide range of materials and techniques that are available for different clinical situations.

Reddy SM, Mohan CA, Vijitha D, Balasubramanian R, Satish A, Kumar M (2012)[42] The study was done to evaluate the pressure applied on the residual ridge while making impressions with two tray design (with and without spacer) using ZOE and light body

PVS impression material. The pressure produced where calibrated according to the microstrain record. From the study it was concluded that (i) A relief space of one sheet thickness of modelling wax was sufficient to reduce the pressure exerted on the residual alveolar ridge while making edentulous impressions. (ii)The pressure applied in the vault of the palate was significantly higher than that applied on the ridge crest which emphasizes the need for vent holes. (iii)Both the ZOE impression paste and light body PVS produced equivalent pressures during impression making under similar special tray designs.

Kakatkar VR (2013)[42] A questionnaire survey was carried out to know which materials used by private practitioners to make impressions and what techniques being followed. The questionnaire was send to Goa, dental practitioners. The dental surgeons were from Pune, Mumbai, Goa, Satasa, Nashik, Indore, Jodhipur, Nanded, Aurangabad, Sangli, Kolhapur. From the survey it was concluded that a satisfactory impression technique can be suggested. A primary impression in alginate or impression compound can be made. A final impression in a tray material or cold cure custom tray with border moulding using low fusing compound and final impression using ZOE paste or light body elastomers could be recorded. Use of elastomers to carry out border moulding required les time and was convenient. But properties of oftened green stick and putty elastomers to achieve peripheral seal needs to be investigated.

Nishigawa G, Maruo Y, Irie M, Oka M, Tamada Y, Minagi S (2013)[43] A theoretical model, based on fluid dynamics was developed to measure the impression pressure. Within the limitations of the study, it was concluded that measuring the impression material extruded from escape holes and grooves in tray could potentially be an alternative method of measuring inflation pressure. The transparent tubes enabled clear visual inspection of the magnitude and distribution of pressure during impression tray seating on the edentulous arch.

Gupta A, Singhal P, Negi P (2014)[3] Impression is basically an interaction between tissues and impression materials. Various impression techniques have been mentioned in the literature for recording impression of edentulous ridges, in that selective pressure technique has got much attention in the literature. This article is about the critical review on the selective pressure impression technique used for edentulous patients. The idea was to vary the pressure over the denture seat(which is a single unit) depending on the displacability of the supporting tissues and hence transferring the load over the selected areas of the seat.

Amjad H JK, Muhammad F (2014)[44] The aim of the survey was to identify the current trends in complete denture impression making and to determine which techniques and materials were used and taught in pakistani undergraduate clinical prosthodontics. A questionnaire was prepared and distributed among 750 dentists belonging to different regions of the country. The findings from this study showed that impression techniques and materials used in the fabrication of complete denture in the existing prosthodontic curriculum required modifications in order to raise the standard of undergraduate dental program.

Kawara M, Iwasaki M, Iwata Y, Komoda Y, Inoue S, Komiyama O et al (2015)[45] The selective pressure impression technique was recommended for removable prosthodontics. The objective of this study was to clarify the viscoelastic rheological properties of impression materials by focusing on tray seating from the study, it was concluded that G' the value that indicates the viscous nature of the material, even immediately after mixing and the accurate impression making time was determined from the results of tan δ values obtained by dividing G" and G'. These results provide unique insight into the selective impression technique and will contribute to the practice of prosthodontics from the view point of preserving the edentulous residual ridge.

Re D, De Angelis F, Augusti G, Augusti D, Caputi S, D'Amario M, D'Arcangelo C (2015)[46] Although new elastomeric impression materials have been introduced into the market, there is still insufficient data about their mechanical properties. The tensile properties of 17 hydrophilic impression materials with different consistencies were compared. 12 Vinyl polysiloxane 2polyether 3 hybrid vinyl polyether silicone based impression materials were tested. From the study it was concluded that the choice of an impression material should be based on the specific physical behaviour of the elastomer. The light body Vinyl polyether silicone showed high tensile strength, yield strength and adequate strain at yield/ brake; those features may help to reduce tearing phenomena in the interproximal and crevicular areas.

Shah RJ, Lagdive SB, Barajod PK, Patel MN (2015)[47] The purpose of the study was to survey dental practitioners along the state of Gujarat for complete denture impression materials and techniques. A questionnaire consisting of 20 questions regarding the complete denture impression procedures was prepared for the purpose of an online survey. Based on the results of the study and within its limitations the following conclusions were drawn: (i) The most commonly used material for making preliminary impression was impression compound in a stock metal tray. (ii)Most dentists performed final Impressions in a border molded custom tray made of auto polymerizing acrylic resin fabricated few hours before the procedure. (iii)Selective pressure theory was the predominant impression philosophy used by the respondents with a majority using spacer and relief holes in the design of custom tray. (iv)Most commonly used material for border molding and final impression where modelling plastic impression compound and zinc oxide eugenol paste respectively. (v)A majority of dentist made a special consideration for excessive movable (flabby) tissue.

Alqattan WA, Alalawi HA, Khan ZA (2016)[48] The aim of this study was to assess present practice concerning impression techniques and materials used for making complete denture in Saudi Arabia. A questionnaire study with 22 questions associated with straight forward complete denture construction and the 8 demographic questions such as age, gender, nationality, graduation college, working place /position, region and years of practice was formulated and circulated. From the study it was concluded that there was significant differences towards specific materials or techniques, which revealed different clinical preferences in construction of conventional complete dentures. This study also showed the dominance of use of Irreversible hydrocolloid in primary impression making which coincide with normal practices all over the world.

Chopra S, Gupta NK, Tandan A, Dwivedi R, Gupta S, Agarwal G (2016)[49] This study was to compare the pressure on mucosa using selective pressure technique and minimal pressure technique with the incorporation of two different impression materials utilizing the pressure sensors during secondary impression. From the study it was concluded that light body vinyl polysiloxane produced significantly lesser pressure than zinc oxide eugenol impression material and the presence of relief did affect the magnitude of pressure at various locations.

Imani fouladi et al (2016)[4] This study aimed to evaluate the effect of vent size and spacer thickness on pressure applied to edentulous maxillary mucosa during impression making with regular body addition silicone impression materials and zinc oxide eugenol. From the study it was concluded that impression material and tray design significantly affect the pressure applied to the tissues during impression making and the pressure applied to the tissues was less in use of regular body addition silicone compared to zinc oxide eugenol in this study. As the vent size and thickness of spacer increased, pressure applied to tissues at different sites decreased. To make an impression of an edentulous maxilla, a tray with a vent 1mm or larger in diameter and a spacer with 1.5mm thickness was recommended, for impression making.

Iwasaki M, Kawara M, Inoue S, Komiyama O, Iida T, Asano T (2016)[5] The purpose of the study was to compare the pressure dynamics in the trays caused by differences in the various impression materials and in the thickness of the relief provided for the trays. Pressure sensors were embedded at eight locations in a model of an edentulous maxilla and used a simulation model covered with pseudomonas. From the study it was concluded that making the final impression for the denture using the selective pressure technique, with considerations given to the pressure dynamics may lead to a good outcome in terms of presentation of the alveolar ridge.

Jain AR, Dhanraj M (2016)[50] Proper knowledge of the anatomy of denture bearing areas and the use of custom tray with proper spacer design and its application during impression making is of utmost importance for stable retentive prosthesis that is in harmony with the surrounding and underlying tissues. This review article shows wide range of spacer designs available for different situations. Based on the particular condition the dentist needs to select a spacer design for the success of complete denture therapy.

Kaur H, Nanda A, Verma M, Koli D (2016)[51] Spacer adaptation has an important role in the procedure for making the different impression for complete dentures. This article shows an alternate technique for adapting the spacer, which overcomes the limitations of conventionally used wax spacers. Instead of wax spacer a resilient polyvinyl sheet using the vaccum forming machine on the cast was used as a spacer. This technique of spacer adaptation overcomes the variability in the thickness of the wax spacer.

Inoue S, Kawara M, Iida T, Iwasaki M, Komiyama O (2017)[52] In edentulous patients progression of bone resorption is markedly faster in mandible than in maxilla, and diverse changes occur in the ridges of the mandible. The aim of the study was to evaluate the effect of tray design and impression material on impression pressure in an edentulous mandible model that simulates displaceability and to identify optimal selective pressure impression techniques for the edentulous mandible. From the study it was concluded that when making impression of an edentulous mandible, bite pressure on alveolar crest can be alleviated by making an impression with a tray with both relief and escape holes while applying pressure to the buccal shelves and applying almost no pressure to the alveolar crest. These characteristics can suppress ridge resorption in the alveolar crest.

Chang Y, Maeda Y, Wada M, Gonda T, Ikebe K, Chang Y, Maeda Y, Wada M, Gonda T, Ikebe K (2018)[53] The purpose of this study was to clarify the influence of the morphology of the residual alveolar ridge, including different mucosal thickness and alveolar bone shapes and sizes, on the pressure distribution during impression procedures. Within the limitations of this experimental study, the following conclusions were obtained. Pressure was not concentrated on sharp edges and inflection points of a slope of bone surface during the impression procedure. Pressure was more evenly distributed when the mucosal thickness increased, while the distribution pattern varied with the bone morphology. The bone morphology underneath the mucosa can have a large influence on the pressure distribution during the impression procedure.

MATERIALS :

Vinyl polysiloxane impression material, Type 3: light-bodied consistency – Hydrophilic, Reprosil – Dentsply caulk (fig.1)

Polyether impression material, Type 2: medium-bodied consistency – Hydrophilic, 3M ESPE – Impregum soft. (fig.2)

Soft-liner, Tissue conditioner, Acryton, Orthoplast. (fig.3)

Autopolymerizing Polymethylmethacrylate (PMMA), DPI – RR cold cure (fig.4)

Modelling baseplate wax NO.2, The Hindustan dental products (fig.5)

Type III dental stone, kalabhai karson private limited, Mumbai. (fig.6)

Vinyl polysiloxane(A-silicone) duplicating material,Elite Double 8, Zhermack. (fig.7)

Condensation silicone putty material, Zhermack products.(fig.8)

DEVICES: (fig.9 &10)

Force **S**ensing **R**esistor (FSR)- 400, Interlink Electronics.

Printed digital circuit board

Aramentarium : (fig.11&12)

Maxillary Edentulous model

Rubber bowl and spatula

Dental flask and clamp

Wax carver

Wax spatula

Wax knife

Wax gauge

Metal gauge

BP handle and blade

Acrylic mixing jar

Duplicating flask

Long bladed mixing spatula

2 kg weight

Digitally calibrated pressure sensing device:

The pressure applied on different areas of the denture bearing mucosa was determined using the force sensitive resistor (Model FSR 400).[49] The diameter of the active area of resistor was 0.2" (5.00mm) and the thickness was 0.012"(0.3mm). These sensors were connected to electronic components which supports a printed digital circuit board which display the readings achieved, while making secondary impression during the study. [5, 33,52] [fig.9&10]

Fabrication of Edentulous model:

An ideal maxillary edentulous cast was fabricated using type III dental stone, by pouring it into an edentulous mould. The cast was retrieved after its final setting time, according to the manufacturer's instructions. The maxillary cast thus obtained was trimmed and finished using a model trimmer [fig.11]. A uniform thickness of 2mm baseplate wax was adapted to the denture supporting area on the maxillary cast and then a conventional flasking and dewaxing was done [fig.13&14]. After, the dewaxing procedure, as a separating medium petroleum jelly was applied throughout the mould space, and a uniform mix of softliner was packed inside the mould space. After the final set (5 min 30 sec), the flask was separated and a uniform (2mm) layer of soft liner[16,52] was fabricated using the packing method, which was used along with the cast as a maxillary analog for this study. [fig.15]

Duplication of maxillary analog:

Duplication of the maxillary analog in type III dental stone was pursued with vinyl polysiloxane duplicating material using a duplicating flask [fig.16]. The duplicated maxillary analog was later utilized to fabricate special trays of various spacer thicknesses. An ‘I’ shaped spacer design[42,49,52] was used in this study with one sheet thickness[41,49,51] and two sheet thickness of base plate wax, respectively[33,47,51,50]. A total of twenty trays were fabricated for utilizing the selective pressure technique for the secondary impression procedure.

Fabrication of special trays:

Selective pressure technique[3,6,32] was used for the secondary impression procedure in this study. So, an “I” shape spacer design extending anteroposteriorly from incisive papilla to fovea palatine along the mid palatine raphae region[42,49,50] was used and then the special tray was fabricated over it, using autopolymerizing Polymethyl Methacrylate resin. [29,35,41,42,51] [fig.17&18]

Four rectangular pillars were prepared using PMMA resin and these pillars were trimmed to a desired form and attached to the tray – one each in the right and left premolar crestal region and among the remaining 2 pillars 1 in the anterior midline in the crestal region and 1 in the posterior midpalatine region of the tray. These pillars will act as support for stabilizing the load to be used while on making the secondary impression[4,49]. These pillars were duplicated after the desired form was achieved using a Condensation silicone putty index and additional blocks were prepared using this putty index, for the remaining set of trays. [fig.19]

Hence, the tray’s spacer design, tray fabrication and the attachment of the pillars over the tray was similar. Only the spacer thickness varied accordingly for each group. In total 10 trays were fabricated with “I”shaped spacer design with one spacer thickness of baseplate wax and another 10 trays were fabricated with “I” shaped spacer design with two spacer thickness of baseplate wax. Each of the trays were given an identification number, accordingly. So, that the same numbered tray of similar thickness of spacer which was used for the impression of one material was used for the other impression material also.

Before impression making, the spacer wax was removed from the special tray and relief holes of uniform diameter of 2mm(4,31,33) were made with a round bur in the relief region and 1 in the crest of the ridge exactly above the region of the sensor(4,10,29,49). Among the 10 samples, for 5 samples the vent holes were placed in the right and for the other 5 trays the vent holes were placed in the left side of the crest of the ridge in relation to the molar region.

Recording the secondary impression:

Under controlled conditions of temperature & humidity, 3 FSR's (force sensitive resistors) were placed on the maxillary analog. Two sensors were placed over the crest of the ridge, bilaterally in the molar region and one was placed at the centre of the mid palatine raphe region [fig.21] (4,41,49). Two impression materials were used for the secondary impression in this study and they are as follows – Polyether – medium bodied(5,44,48,52) and Vinyl polysiloxane light body impression material(5,29,35,41,44,48,52).

The Vinyl polysiloxane impression material was carefully loaded onto the special tray with single spacer thickness and a 2 kg weight(5,29,52) was placed on the loaded tray, over the analog. The pillars that were prepared acted as a support for the weight that was loaded during the impression procedure. The pressure readings were noted in all the three pressure sensors during the impression making procedure at the initial seating and after the final set(16,33,49) [fig.22]. Likewise the impression was carried out throughout the group for the single spacer thickness trays, which were numbered sequentially. After completing impressions of the single spacer group with VPS, the same trays were sequentially used for making impressions with Polyether. Similarly secondary impressions were made with the group of trays with double spacer thickness, with Vinyl polysiloxane and with the same numbered trays the impression was carried out with the polyether impression material, in a sequential manner. [fig.23-26]

Total of forty samples were made as per following distribution

Grouping of samples:

The sensors were positioned as follows: f1 – right crest region, f2 – left crest region, f3 – palatal region. For each samples, three readings at locations f1, f2 and f3 were recorded.

Samples n= 40

GROUP I: Vinyl polysiloxane impression material group

I A: Vinyl polysiloxane impression material with single spacer thickness

I B: Vinyl polysiloxane impression material with double spacer thickness

GROUP II: Polyether impression material group

II A: Polyether impression material with single spacer thickness

II B: Polyether impression material with double spacer thickness

For all the groups the samples were subdivided to evaluate the significance of the vent placed on the crest region. So, among the 10 samples in each group, for 5 samples the vent holes were placed in the left crest region and for the remaining 5 samples the vent holes were placed on the right crest region, respectively .

Fig.1 : Vinyl polysiloxane impression material **Fig.2 :** Polyether impression material

Fig.3: Soft liner, Tissue conditioner

Fig.4: Autopolymerizing Polymethylmethacrylate

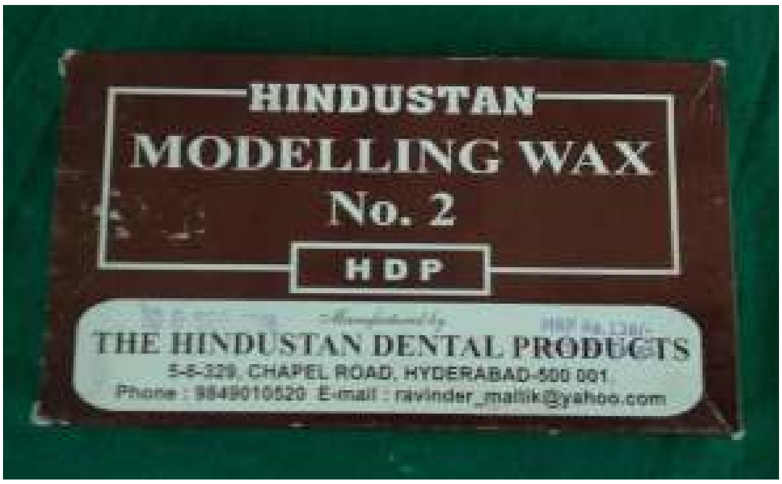


Fig.5: Modelling baseplate wax NO.2

Fig.6: Type III dental stone

Fig.7: Vinyl polysiloxane duplicating material

Fig.8: Condensation silicone putty material

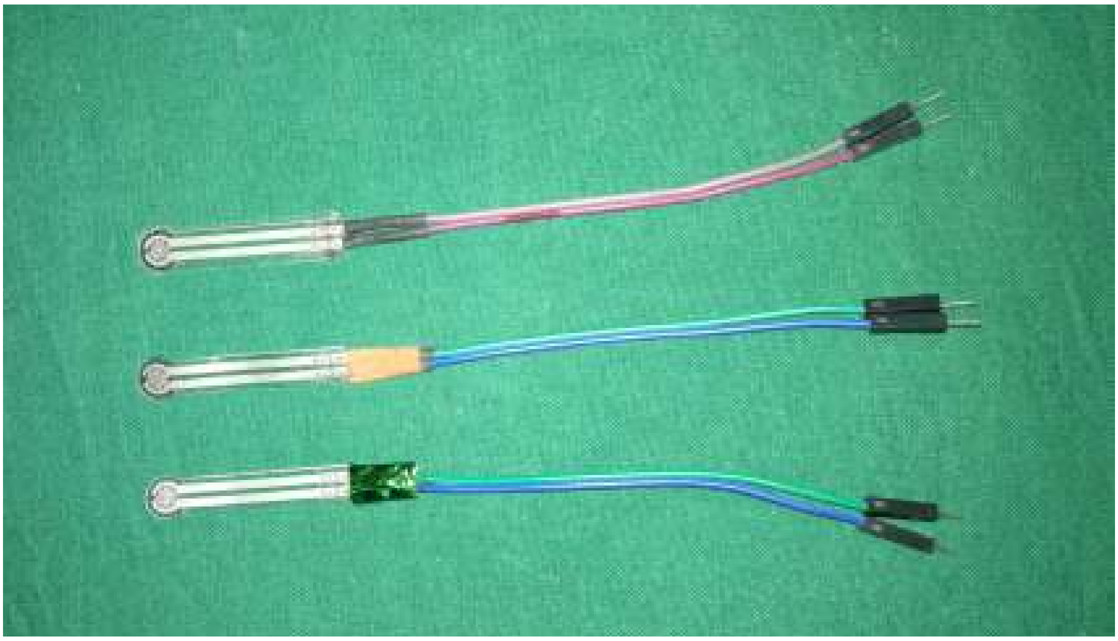


Fig.9: Force Sensing Resistor (FSR) – 400

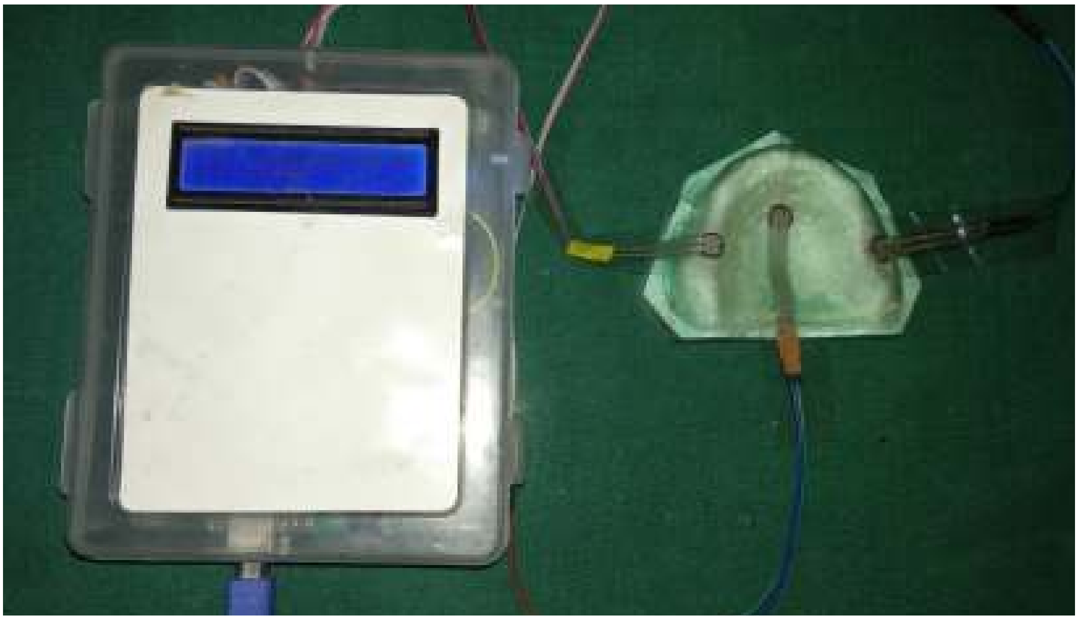


Fig.10: Printed digital circuit board

Fig.11: Maxillary edentulous model

Fig.12: Armamentarium

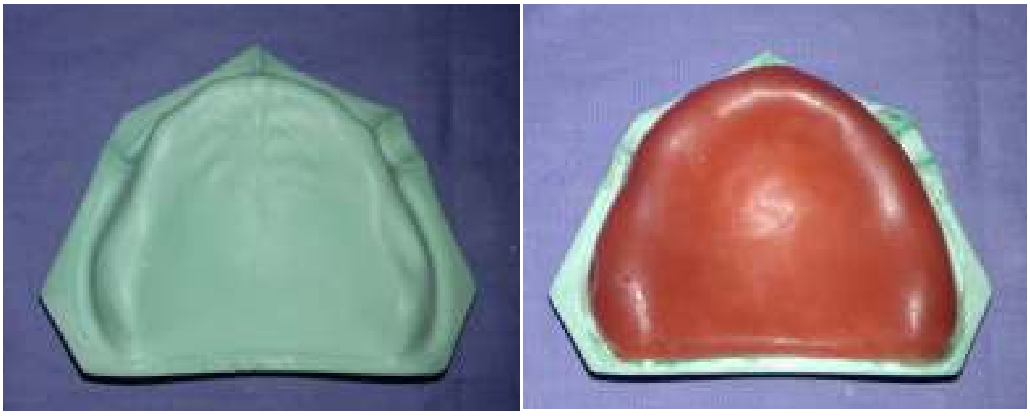


Fig.13: Maxillary edentulous model and 2mm uniform thickness wax spacer after adaptation

Fig.14: Conventional flasking and dewaxing was done

Fig.15: Cast with soft liner

Fig.16: Duplication of maxillary analog with soft liner

Fig.17: "I" shaped spacer design

Fig.18: Special tray fabrication with pillars

Fig.19: Putty index for fabrication of pillars

Fig.20: Metal gauge measuring 2mm Round Bur

Fig.21: Device along with sensor positioned in analog

Fig.22: Digitally readings were acquired after placing 2kg weight

Fig.23: VPS group with double spacer

Fig.24: VPS group with single spacer

Fig.25: Polyether group with single spacer

Fig.26: Polyether group with double spacer

The values of pressure exerted on different areas of a maxillary analog were tabulated. The pressure sensors were labelled as f1, f2 and f3. These sensors were positioned as follows: f1- right crest region, f2- left crest region, f3- palate region.

Comparison of two groups

Student's "t" test for two independent groups was used to compare the significance of difference between two groups at 5% level of significance.

Note 1: If "p" value is more than 0.05, then we can conclude that there is no significant difference between the two groups, considered with regard to mean.

Note 2: If "p" value is less than 0.05, then we can conclude that there is a significant difference between the two groups, considered with regard to mean.

Comparison of more than two groups

Analysis of variance (ANOVA) test was used to compare the significance of difference between more than two groups at 5% level of significance.

Note 1: If "p" value is more than 0.05, then we can conclude that there is no significant difference between the two groups, considered with regard to mean.

Note 2: If "p" value is less than 0.05, then we can conclude that there is a significant difference between the two groups, considered with regard to mean.

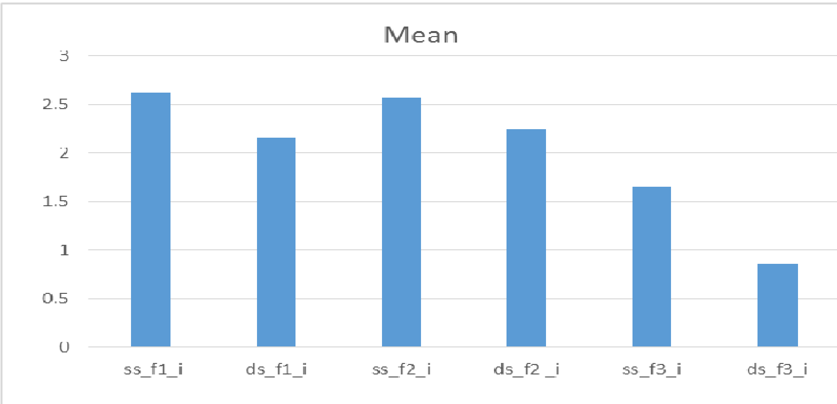
In this study, both ANOVA test and student t test were used.

COMPARISON BETWEEN SINGLE SPACER AND DOUBLE SPACER THICKNESS (INITIAL PRESSURE) IN VINYL POLYSILOXANE GROUP

[ss- single spacer silicone, ds- double spacer silicone, i-initial pressure, f1- right crest region, f2- left crest region, f3- palate region]

VAR00007	N	Mean	Std. Deviation	Std. Error Mean
ss_f1 _i	10	2.615	0.28818	0.09113
ds_f1 _i	10	2.156	0.60434	0.19111
ss_f2 _i	10	2.567	0.18288	0.05783
ds_f2 _i	10	2.244	0.25413	0.08036
ss_f3 _i	10	1.655	0.27496	0.08695
ds_f3 _i	10	0.863	0.23372	0.07391

Table 1: Group statistics for initial pressure of both spacer thickness in VPS group



Graph 1: Comparision between mean values of initial pressure exerted in both sapcer thickness of VPS group

	t	df	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
ss_f1_i	2.168	18	**0.044**	0.21173	0.01418	0.90382
ds_f1_i	2.168	12.892	**0.049**	0.21173	0.0012	0.9168
ss_f2 _i	3.262	18	**0.004**	0.09901	0.11499	0.53101
ds_f2_i	3.262	16.35	**0.005**	0.09901	0.11348	0.53252
ss_f3 _i	6.94	18	**0.000**	0.11412	0.55225	1.03175
ds_f3_i	6.94	17.545	**0.000**	0.11412	0.5518	1.0322

Table 2: Statistical analysis for Comparision of initial pressure exerted in both sapcer thickness of VPS group

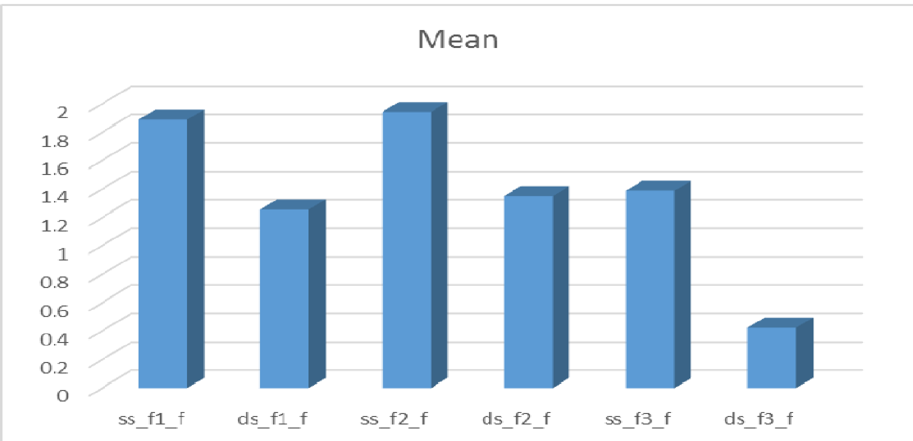
Inference: Since the p value for f1, f2, f3 region for initial pressure of both the single spacer and double spacer thickness for vinyl polysiloxane material is less than 0.05, it can be concluded that there is a significant difference between these two spacer thicknesses.

From the mean difference it was evident that the initial pressure exerted for double spacer thickness is less when compared to single spacer thickness for vinyl polysiloxane material

COMPARISON BETWEEN SINGLE SPACER AND DOUBLE SPACER THICKNESS (FINAL PRESSURE) IN VINYL POLYSILOXANE GROUP [ss- single spacer silicone, ds- double spacer silicone, f –final pressure, f1- right crest region, f2- left crest region, f3- palate region]

VAR00007	N	Mean	Std. Deviation	Std. Error Mean
ss_f1_f	10	1.887	0.22076	0.06981
ds_f1_f	10	1.255	1.04134	0.3293
ss_f2_f	10	1.941	0.29187	0.0923
ds_f2_f	10	1.35	0.46275	0.14633
ss_f3_f	10	1.389	0.33271	0.10521
ds_f3_f	10	0.424	0.28695	0.09074

Table 3: Group statistics for final pressure of both spacer thickness in VPS group



Graph 2: Comparision between mean values of final pressure exerted in both sapcer thickness of VPS group

	t	df	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
ss_f1_f	1.877	18	0.077	0.33662	-0.07521	1.33921
ds_f1_f	1.877	9.807	0.090	0.33662	-0.12003	1.38403
ss_f2_f	3.416	18	**0.003**	0.17301	0.22752	0.95448
ds_f2_f	3.416	15.182	**0.004**	0.17301	0.22263	0.95937
ss_f3_f	6.946	18	**0.000**	0.13894	0.6731	1.2569
ds_f3_f	6.946	17.62	**0.000**	0.13894	0.67265	1.25735

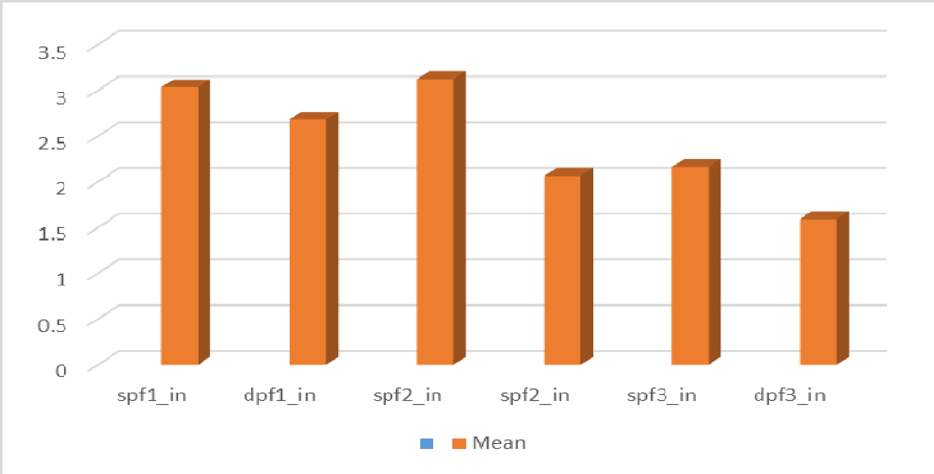
Table 4: Statistical analysis for Comparision of final pressure exerted in both sapcer thickness of VPS group

Inference: Since the p values for f2, f3 regions at final pressure of both the single spacer and double spacer thickness for vinyl polysiloxane material was less than 0.05, it can be concluded that there is a significant difference between these two spacer thicknesses in f2- left crest region and f3- palatal region. But for the f1- right crest region, the final pressure exerted for both the spacer thicknesses was not statistically significant. Although there is a difference in the mean for f1, it was not statistically significant. From the mean difference it was evident that the final pressure exerted for double spacer thicknesses is less when compared to single spacer thickness for vinyl polysiloxane material.

COMPARISON BETWEEN SINGLE SPACER AND DOUBLE SPACER THICKNESS (INITIAL PRESSURE) IN POLYETHER GROUP [sp- single spacer polyether, ds- double spacer polyether, in- initial pressure, f1- right crest region, f2- left crest region, f3- palate region]

VAR00007	N	Mean	Std. Deviation	Std. Error Mean
spf1_in	10	3.034	0.57225	0.18096
dpf1_in	10	2.679	0.40204	0.12713
spf2_in	10	3.124	0.52109	0.16478
dpf2_in	10	2.066	0.59846	0.18925
spf3_in	10	2.163	0.17827	0.05637
dpf3_in	10	1.592	0.12246	0.03872

Table 5: Group statistics for initial pressure of both spacer thickness in PE group



Graph 3: Comparision between mean values of initial pressure exerted in both sapcer thickness of PE group

	t	df	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
spf1_in	1.605	18	0.126	0.22116	-0.10963	0.81963
dpf1_in	1.605	16.144	0.128	0.22116	-0.11349	0.82349
spf2_in	4.216	18	**0.001**	0.25094	0.5308	1.5852
dpf2_in	4.216	17.666	**0.001**	0.25094	0.53008	1.58592
spf3_in	8.349	18	**0.000**	0.06839	0.42731	0.71469
dpf3_in	8.349	15.947	**0.000**	0.06839	0.42598	0.71602

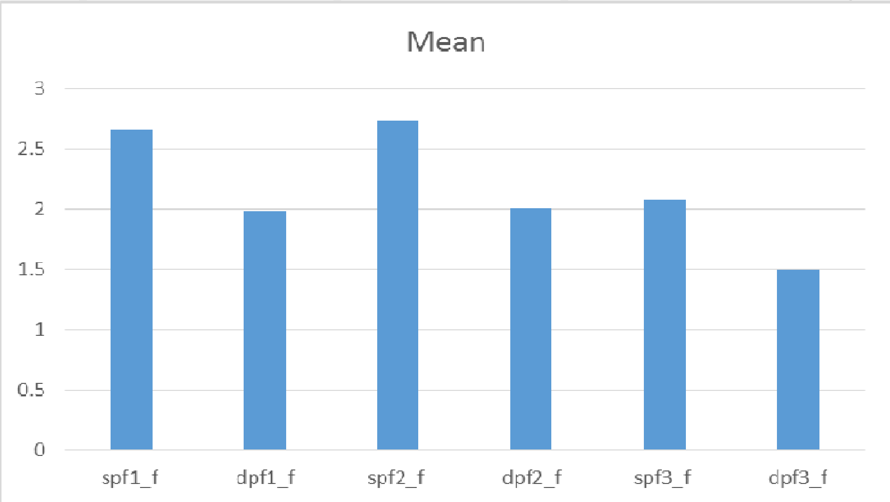
Table 6: Statistical analysis for Comparision of initial pressure exerted in both sapcer thickness of PE group

Inference: since the p value for f2- left crest region, f3- palatal region for initial pressure of both the single spacer and double spacer thickness for polyether material is less than 0.05, it can be concluded that there is a significant difference between these two spacer thicknesses. But for the f1- right crest region, there was no significant difference in the the initial pressure exerted for both the spacer thicknesses. Although there was a difference in the mean for f1, it was not statistically significant.

COMPARISON BETWEEN SINGLE SPACER AND DOUBLE SPACER THICKNESS (FINAL PRESSURE) IN POLYETHER GROUP [sp- single spacer polyether, ds- double spacer polyether, f- final pressure, f1- right crest region, f2- left crest region, f3- palate region]

	N	Mean	Std. Deviation	Std. Error Mean
spf1_f	10	2.66	0.56864	0.17982
dpf1_f	10	1.988	0.65633	0.20755
spf2_f	10	2.73	0.45646	0.14435
dpf2_f	10	2	0.62732	0.19838
spf3_f	10	2.082	0.09531	0.03014
dpf3_f	10	1.494	0.27097	0.08569

Table 7: Group statistics for final pressure of both spacer thickness in PE group



Graph 4: Comparision between mean values of final pressure exerted in both sapcer thickness of PE group

	t	df	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
spf1_f	2.447	18	**0.025**	0.27461	0.09506	1.24894
dpf1_f	2.447	17.642	**0.025**	0.27461	0.09422	1.24978
spf2_f	2.976	18	**0.008**	0.24533	0.21457	1.24543
dpf2_f	2.976	16.444	**0.009**	0.24533	0.21105	1.24895
spf3_f	6.473	18	**0.000**	0.09084	0.39716	0.77884
dpf3_f	6.473	11.193	**0.000**	0.09084	0.38849	0.78751

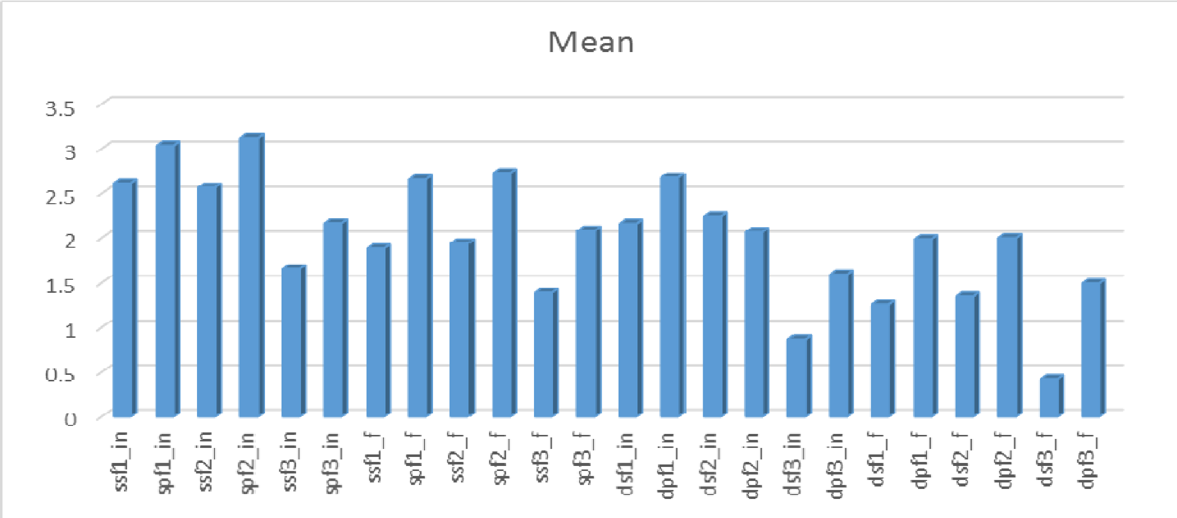
Table 8: Statistical analysis for Comparision of final pressure exerted in both sapcer thickness of PE group

Inference: since the p value for f1, f2, f3 region for final pressure of both the single spacer and double spacer thicknesses for polyether material was less than 0.05, it can be concluded that there is a significant difference between these two spacer thicknesses for polyether impression material. From the mean it was evident that the double spacer thickness exerted less pressure than single spacer thickness, for polyether impression material.

COMPARISON OF PRESSURE EXERTED BETWEEN THE GROUP 1: VPS, AND GROUP 2: POLYETHER, FOR SINGLE AND DOUBLE SPACER THICKNESSES: [ss- single spacer silicone, ds- double spacer silicone, sp- single spacer polyether, ds- double spacer polyether, i- initial pressure f- final pressure, f1- right crest region, f2- left crest region, f3- palate region]

VAR00007	N	Mean	Std. Deviation	Std. Error Mean
ssf1_in	10	2.615	0.28818	0.09113
spf1_in	10	3.034	0.57225	0.18096
ssf2_in	10	2.567	0.18288	0.05783
spf2_in	10	3.124	0.52109	0.16478
ssf3_in	10	1.655	0.27496	0.08695
spf3_in	10	2.163	0.17827	0.05637
ssf1_f	10	1.887	0.22076	0.06981
spf1_f	10	2.66	0.56864	0.17982
ssf2_f	10	1.941	0.29187	0.0923
spf2_f	10	2.73	0.45646	0.14435
ssf3_f	10	1.389	0.33271	0.10521
spf3_f	10	2.082	0.09531	0.03014
dsf1_in	10	2.156	0.60434	0.19111
dpf1_in	10	2.679	0.40204	0.12713
dsf2_in	10	2.244	0.25413	0.08036
dpf2_in	10	2.066	0.59846	0.18925
dsf3_in	10	0.863	0.23372	0.07391
dpf3_in	10	1.592	0.12246	0.03872
dsf1_f	10	1.255	1.04134	0.3293
dpf1_f	10	1.988	0.65633	0.20755
dsf2_f	10	1.35	0.46275	0.14633
dpf2_f	10	2	0.62732	0.19838
dsf3_f	10	0.424	0.28695	0.09074
dpf3_f	10	1.494	0.27097	0.08569

Table 9: Group statistics for comparison of pressure exerted between the VPS group and Polyether group for single and double spacer thicknesses



Graph 5: Comparison of pressure exerted between the VPS group and Polyether group for single and double spacer thicknesses

	t	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
				Lower	Upper
ssf1_in	-2.068	0.053	0.20261	-0.84467	0.00667
spf1_in	-2.068	0.059	0.20261	-0.85575	0.01775
ssf2_in	-3.189	**0.005**	0.17464	-0.9239	-0.1901
spf2_in	-3.189	**0.008**	0.17464	-0.94061	-0.17339
ssf3_in	-4.902	**0.000**	0.10363	-0.72571	-0.29029
spf3_in	-4.902	**0.000**	0.10363	-0.72834	-0.28766
ssf1_f	-4.007	**0.001**	0.1929	-1.17826	-0.36774
spf1_ f	-4.007	**0.002**	0.1929	-1.19468	-0.35132
ssf2_f	-4.605	**0.000**	0.17133	-1.14895	-0.42905
spf2_f	-4.605	**0.000**	0.17133	-1.15355	-0.42445
ssf3_f	-6.332	**0.000**	0.10945	-0.92294	-0.46306
spf3_f	-6.332	**0.000**	0.10945	-0.93539	-0.45061
dsf1_in	-2.279	**0.035**	0.22953	-1.00523	-0.04077
dpf1_in	-2.279	**0.037**	0.22953	-1.01045	-0.03555
dsf2_in	0.866	0.398	0.20561	-0.25396	0.60996
dpf2_in	0.866	0.403	0.20561	-0.26939	0.62539
dsf3_in	-8.737	**0.000**	0.08344	-0.9043	-0.5537
dpf3_in	-8.737	**0.000**	0.08344	-0.90846	-0.54954
dsf1_f	-1.883	0.076	0.38925	-1.55078	0.08478
dpf1_f	-1.883	0.079	0.38925	-1.56183	0.09583
dsf2_f	-2.637	**0.017**	0.24651	-1.1679	-0.1321
dpf2_f	-2.637	**0.018**	0.24651	-1.17115	-0.12885
dsf3_f	-8.573	**0.000**	0.12481	-1.33221	-0.80779
dpf3_f	-8.573	**0.000**	0.12481	-1.33227	-0.80773

Table 10: Statistical analysis for comparison of pressure exerted between the VPS group and Polyether group for single and double spacer thicknesses

Inference: There was significant difference in the initial pressure exerted in all the three regions of a maxillary analog except the f1- right crest region for single spacer thickness of both the groups. Whereas for double spacer thickness of both the groups, there was significant difference in the initial pressure exerted in all the three regions of a maxillary analog except the f2- left crest region.

Regarding the final pressure, there was significant difference in the pressure exerted in all the three regions i.e., f1, f2, f3 of single spacer thickness for both the groups. Whereas for double spacer thickness, there was no significant difference was found in the pressure exerted in the f1- right crest region.

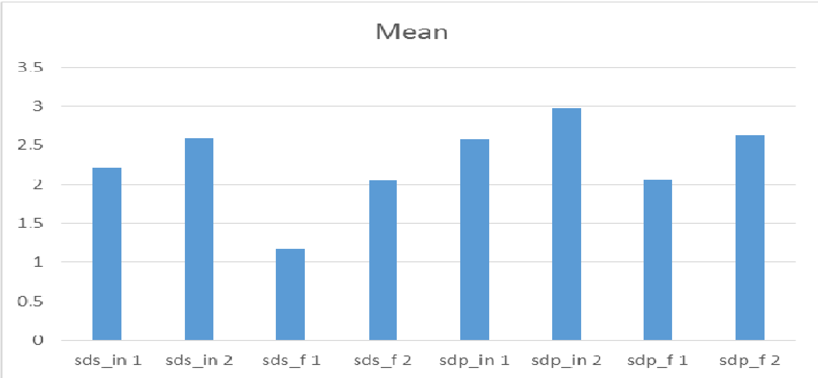
From the mean difference between the two groups, it was evident that the vinyl polysiloxane material group exerted less pressure when compared to Polyether material group. On the whole, VPS material with double spacer thickness exerted less pressure when compared to other groups.

COMPARISON OF PRESSURE EXERTED ON THE CREST AREAS TO EVALUATE IF THERE WAS A SIGNIFICANT DIFFERENCE BECAUSE OF THE PRESENCE OF VENT HOLES, FOR BOTH THE SPACER THICKNESSES, OF VPS AND POLYETHER GROUPS:

[sds – single and double spacer silicone, sdp- single and double spacer polyether , i- initial pressure, f- final pressure, 1- with vent hole, 2 – without vent hole]

gr		N	Mean	Std. Deviation	Std. Error Mean
sds_in	1	20	2.204	0.38343	0.08574
	2	20	2.587	0.34302	0.0767
sds_f	1	20	1.171	0.61826	0.13825
	2	20	2.0455	0.30614	0.06845
sdp_in	1	20	2.5715	0.54812	0.12256
	2	20	2.9765	0.51447	0.11504
sdp_f	1	20	2.0635	0.69379	0.15514
	2	20	2.6255	0.50469	0.11285

Table 11: Group statistics for comparision of pressure exerted on the crest region with vent hole and without vent hole for both the spacer thickness of VPS and PE group.



1= with vent hole 2= without vent hole

Graph 6: Comparision of pressure exerted on the crest region with vent hole and without vent hole for both the spacer thicknesses of VPS and PE group.

		t	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
sds_in	1	-3.329	**0.002**	0.11504	-0.61588	-0.15012
	2	-3.329	**0.002**	0.11504	-0.61598	-0.15002
sds_f	1	-5.669	**0.000**	0.15427	-1.1868	-0.5622
	2	-5.669	**0.000**	0.15427	-1.19061	-0.55839
sdp_in	1	-2.409	**0.021**	0.16809	-0.74529	-0.06471
	2	-2.409	**0.021**	0.16809	-0.74533	-0.06467
sdp_f	1	-2.93	**0.006**	0.19184	-0.95036	-0.17364
	2	-2.93	**0.006**	0.19184	-0.95157	-0.17243

Table 12: Statistical analysis for comparision of pressure exerted on the crest region with vent hole and without vent hole for both the spacer thicknesses of VPS and PE group.

Inference: When comparing the samples with and without vent holes on the crest areas, there was significant difference for both VPS group and Polyether group, at initial and final pressure. From the mean it was evident that there was a significant reduction in pressure in the area of the vent hole when compared to the area without the vent hole, for both the spacer thicknesses, of both VPS and Polyether groups.

The use of selected pressure technique was recommended by Boucher for edentulous residual alveolar ridges. The important objectives of impression making is (“PRESS”) – **P**reservation of alveolar ridges, **R**etention, **E**sthetics, **S**tability, **S**upport. These objectives can only be fulfilled by thoroughly understanding the underlying oral anatomy and histological features of the structures involved during impression making.

The outer surface of the bone in the crest of the residual ridge of the maxillae is compact in nature, since it is made up of Haversian systems. Histologically, these features of compact bone with the tightly attached mucous membrane, in the crest of the ridge in the maxillary arch makes it a suitable area to provide primary support for the maxillary denture.The soft tissue covering the hard palate varies in consistency and thickness at different locations. Posterolaterally, the submucosa contains glandular tissue and Anterolaterally, the submucosa of the hard palate contains adipose tissue. So, these tissues should be recorded in a resting condition, because when these tissues are displaced during the impression procedure, they tend to return to their normal form within the completed denture base, creating an unseating force on the denture, leading to soreness. The submucosa in the medain palatalal suture region is extremely thin, and the mucosal layer is almost in contact with the underlying bone. So, little or no stress should be placed in this region while on making the secondary impression. Otherwise, the denture may rock over the center of the palate when the vertical forces are applied on the denture teeth. In addition, the center of the palatal region is highly sensitive, and excess pressure can be painful. Due to these variations selectively placing pressure on the mucous membrane and areas that are compatible with supporting tissues which have histologically stress bearing capability are utilized during the impression procedure.[33]

With respect to the tissue surface it is also important to give similar attention to the impression technique and the materials that we use during the impression procedure. An impression material should allow accurate recording of these structures with minimal tissue displacement. The pressure exerted during impression making may be partly due to the approximation of the tray to the oral tissues and partly due to the viscosity of the impression material. Pressure, a boon and a bane, is an integral part of impression. Pressure makes the material to flow throughout the tray and facilitates intimate contact with the tissues to be recorded. This intimate tissue contact aids in achieving a very important objective that is Retention.[49]

According to Boucher[9], there is no single “best” impression technique for complete denture fabrication. The wide variety of impression materials used for impression making and their range of working characteristics, make possible the development of impression procedures best suited for specific conditions existing in relation to the denture base foundation. Blindly following a technique for all clinical situations will not produce better results, so an impression technique has to be selected according to the existing clinical condition of that particular patient. A technique has to be in an orderly sequence, but not a dictator.

De Van MM[34] has stated that, ‘there would not be a problem if we were taking impression of casts. The problem is due to the fact that the mouth is lined with tissues that vary in degree of displacability, thickness, rigidity and the point of application, magnitude, and direction, of the forces applied on it. By assessing these facts, it is reasonable to say that the ideal impression must be in the mind of the dentist before it is in the hand. The dentist must literally make the impression rather than take it. According to Page, while making an impression, the soft tissues should be registered in an unstrained rest position, otherwise the tissues will be compelled to regain their rest position, leading to dislodgement of the denture.

For complete denture impression techniques, we have been provided with a set of philosophies – "No pressure, Minimal Pressure, Definitive Pressure and Selective pressure". However none of these impression theories have been designated as the 'time best' for a particular patient though Selective pressure theory has received much attention in the literature. The method advocated to achieve selected pressure is by altering the spacer thickness which thereby increases space for the impression material also, in the selected areas. By altering the thickness of the spacer, a narrow lumen exists between the special tray and the seat. Bone reacts to the slight distortion caused by this pressure in the form of elastic forces which resists compression(3). Woelfel(15) concluded in his study that, to produce an excellent final impression the placement of the spacer and the escape holes in an impression tray are far more important factors than the choice of a corrective wash material. He reinforced that the tray should be modified accordingly to meet the requirements of the specific type of wash material used.

The limitations of selective pressure technique are that we cannot standardize the finger pressure while on impression making. In addition to that, when we use a thixotrophic material for impression making, the viscosity of the material is increased by applying pressure so that it flows when it contacts with the tissues, under finger pressure. But as soon as the material starts flowing out of the borders, finger pressure is released. So, the only pressure that remains will be, by the virtue of the viscosity of the material or the frictional forces. The spacer design also varies in the literature and there is no sound proof for explaining that the different thickness of spacer could lead to a change in pressure in a custom tray. There are variations in texts regarding the stress bearing areas also. So, there are many areas of concern regarding the selective pressure application technique. [(3)]

Hence this study was undertaken to evaluate the pressure generated on a maxillary analog while making an impression with selective pressure technique for two different spacer thicknesses of similar tray design, with two different impression materials. Along with that, the significance of vent holes in minimizing the exerted pressure during impression making was also evaluated.

Chopra et al.,[(49)] conducted an in vitro study to evaluate the effect of two different impression materials and tray design on the pressure exerted on various areas of denture bearing tissues. The study was performed on a maxillary analogue. Three pressure sensors were positioned in the analog, one each in the right and left ridge crest and one in the mid palatine area. Two different tray configurations were fabricated i.e., minimal pressure and selective pressure and two different impression materials i.e, ZOE and PVS light body material was used for the study. A constant 1 kg weight was placed, and the pressure was recorded as initial and end pressures. From the study it was concluded that the design of the spacer and the use of the escape hole as well as the type of the impression materials had a significant influence on the pressure exerted on the denture bearing areas during impression procedure. It was evident that the selective pressure technique showed a significant reduction in pressure exerted in the mid palatine region than in the crest region when compared to minimal pressure technique.

Based on this earlier study, certain modifications were done in our study which were as follows; the impression technique adopted was a selective pressure technique[3,6,32], since it was evident that there was significant reduction in pressure in the relief areas when compared to the stress bearing areas. The spacer design was an "I"- shaped spacer[42,49,50] relieving the incisive papilla and the mid palatine raphae region with two different spacer thickness i.e., single spacer thickness and double spacer thickness[33,41,49-51]. The impression material used was Polyether[5,44,48,52] and Polyvinyl siloxane light body impression material[5,29,35,41,44,48,52]. The load used to simulate the tray seating load was a constant weight of 2 kg[5,29,52].

Polyether impression material has been commonly used as a wash impression material for fabricating satisfactorily functioning dentures. It is a hydrophilic material thereby providing a more accurate impression even in moist conditions. Polyether is more prevalent among clinicians when compared to zinc oxide eugenol because of its biocompatibility, acceptable odor and taste, good detail reproduction, good tear strength, easy removal of impression, sufficient working time with a short setting time and a long shelf life. So, Polyether was chosen as a material for making impressions, in this study.

The second material used in this study was Vinyl polysiloxane light body. This is also a hydrophilic material, so the working characteristic in moist condition is an enhanced property. Although they are considered to be one among the most expensive materials, they are used in a wide variety of situations. Since there are virtually no by-products released during the polymerization reaction, the impressions are dimensionally stable. So, vinyl polysiloxane material was chosen as a material of choice.

In this study the following results were attained for the two above selected impression materials, using two different spacer thicknessess in a similar tray design. The pressure exerted in the crest of the alveolar ridge (f1, f2) was less when compared to the palatal region (f3) for both the spacer thicknessess and for both the impression material. This could be attributed to the presence of spacer and escape hole compared to the crest region. However this study was in accordance with Frank(16) et al., (1969) that the relief space and escape holes also played a significant role in reduction of the amount of pressure exerted, despite that produced by the various impression materials used in the study. Frank had thereby concluded that the impression pressure can be controlled by the tray design and the selected material. The incisive papilla and mid palatine raphae in the palatal region are considered as areas which have to be relieved and thereby these areas in the palatal region should be exerted less pressure when compared to the crest region. This study was in contrary to the study done by Rihani(18) (1981) that the greatest pressure was recorded in the center of the palate and it got diminished on approaching the buccal borders, when recorded by a manometer.

The trays were fabricated with autopolymerizing resin and were stored for 24 hrs for the release of excess monomer(29,35). The wax spacer was then removed and then the tray was loaded with impression material and was positioned on the maxillary analog and then a constant seating load of 2kg was placed on to the tray. The pressure recorded with vinyl polysiloxane impression material for both the spacer thicknesses at initial placement and after final setting were recorded and then compared. From the mean difference, it was evident that the tray with double spacer thickness exerted less pressure when compared to single spacer thickness, for PVS material.

The trays which are used for the VPS group were used for the Polyether material group. The VPS impression material was retrieved from the tray of both spacer thicknesses and it was stored. After evaluating the tray for proper removal of all the residual impression material, the same trays were used for making impressions with Polyether. The same methodology which was carried out earlier for VPS group was followed for polyether group of both the spacer thicknesses with a similar tray design and from the mean it was evident that for the polyether group also the double spacer thickness trays exerted less pressure when compared to the single spacer thickness with a similar tray design.

When comparing the pressure exerted between the two groups i.e., VPS light body and Polyether Medium body, from the mean it was evident that the VPS material exerted less pressure when compared to Polyether group. In that VPS with double spacer thickness exerted less pressure when compared to the other groups. This study was in accordance to the statement given by Iwasaki(5) et al., (2016) that the tray without relief exerted more pressure in the incisive papilla region, regardless of the type of impression material, whereas two paraffin wax reliefs provided a uniform distribution of pressure in the relief area than using one paraffin wax relief. The results from his study suggested that making final impressions using selective pressure gave a good outcome in terms of preservation of alveolar ridge. Another study by Imani Fouladi[4]et al., (2016) concluded that the impression material and tray design significantly affected the pressure applied to tissues during impression making, and also the pressure applied was less when using regular body addition silicone compared to zinc oxide eugenol. As the vent size and thickness of spacer was increased, the pressure applied to the tissues at different areas decreased. So in situations which needed an impression of the edentulous maxilla, a tray with a vent 1mm or larger in diameter and a spacer with 1.5mm thickness, was recommended, to control the pressure exerted during secondary impression procedure. So from the literature it was evident that as the spacer thickness was increased there was a significant reduction in the amount of pressure exerted during the impression procedure.

The pressure exerted in the crest region and the influence of the vent hole was evaluated by placing a vent hole in the crest region on one side for 5 samples and on the other side for 5 samples in the same group for both the single and double spacer thickness in a similar tray design. It was found that there was significant difference in pressure exerted on the crest region with the vent hole to the other side of the crest region without the vent hole, for both single and double spacer thicknesses, of similar tray design, for VPS and Polyether group. From the mean it was evident that there was a significant reduction in pressure in the area of the vent hole when compared to the area without the vent hole, for both the spacer thicknesses, of both VPS and Polyether groups.

From the study it was evident that a tray with 2mm vent hole on the crest region was sufficient to reduce the pressure exerted with both the spacer thicknesses of VPS and Polyether group.

The obtained results from this study was contrary to the study done by Masri[29] et al.,(2002) which measured the pressure under a maxillary impression using 3 different impression materials and 4 impression tray configurations. Tray modifications did not have any significant evidence in changing the amount of pressure produced during impression making. In simple, only the impression materials used, had more effect on the pressure produced rather than the tray design. This study shows that not only does the consistency of the material play a major role in the quantum of pressure produced during the impression procedure, but also the modifications in the spacer thickness, tray design and the number, position and diameter of the vent holes had an important role in reducing the pressure exerted, during impression making.

This study supports the facts proposed by Komiyama[33] et al., (2004) who conducted an in vitro study to evaluate the changes in the impression pressure produced by three different types of relief space: no spacer (NS), o.36mm thick sheet of wax (ss), and 1.40mm thick base plate wax and four different types of escape holes: no hole (NH), o.5mm, 1.0mm, and 2mm diameter hole were made in the acrylic resin tray. It was suggested that for making impression of an edentulous maxilla, a tray with an escape hole of 1.0mm or larger and a spacer thickness of 1.40mm base plate wax may be used to selectively reduce the impression pressure.

In our study the pressure exerted between the initial pressure and the final pressure was evaluated and compared for both the groups. It was found that for the VPS group there was no significant reduction from initial to final pressure, in the region of the palate (f3) for single spacer thickness of VPS group where as for double spacer there was significant reduction in initial to final pressure in all the three regions for a similar tray design. For Polyether group, there was no significant reduction from initial to final pressure for both the spacer thickness in a similar tray design. The initial pressure exerted was less with double spacer thickness when compared to single spacer thickness of similar tray design, whereas in regards to the pressure reduction from initial to final pressure, there was minimal reduction in the double spacer thickness group when compared to single spacer thickness group. As the spacer thickness is increased the quantity of the material with a higher viscosity (medium bodied material, when compared to the low viscosity VPS), has to pass through the lumen before the setting time, to reduce the pressure exerted. As for the light body VPS the lower viscosity of the material permits quicker flow of more bulk of the material through the same lumen within its setting time, thereby reducing the final pressure, substantially. So it would be appropriate to either place larger vent holes or more number of vent holes or reduce the thickness of the wax spacer when Polyether medium bodied is used, to reduce the bulk of material confined within the tray and thereby reduce the final pressure exerted.

However as per this study, the role of spacer thickness and placing vent holes in the special tray as well as the choice of the impression material had a significant effect on the pressure exerted, while making the secondary impression. The “I” shaped spacer design and spacer thickness plays a major role in selectively reducing the pressure exerted during impression making. No study has clearly elicited a definitive technique for achieving selective pressure during impression making. But still further in vivo studies are required to draw a conclusion regarding the definitive procedure for the selective pressure theory for making a secondary impression.

The present in vitro study was carried out to evaluate the changes in the pressure exerted during secondary impression procedure by different impression materials for two different spacer thicknesses in a similar tray design. The significance of the vent hole in the crest region in its presence and absence was evaluated for different impression materials for two different spacer thicknesses, in a similar tray design. The pressure exerted was recorded using a force sensing resistor (fsr-400) which was connected to a digital calibrating device. These sensors were positioned as follows f1- right crest region, f2- left crest region, f3- palatal region. The impression procedure for each group was carried out and the readings at initial set and final set were noted. The result of this study showed statistically significant difference between the groups of different impression material for two different spacer thickness, in a similar tray design.

At the end of the study, the null hypothesis was rejected.

Within the limitations of the study, the following conclusions were drawn:

- For the VPS group, from the values of pressure exerted on different areas during impression making of a edentulous maxillary analog, it was evident that a tray with double spacer thickness exerted less pressure when compared to single spacer thickness, in a similar tray design.
- For the Polyether group, from the values of pressure exerted on different areas during impression making of a edentulous maxillary analog, it was evident that a tray with double spacer thickness exerted less pressure when compared to single spacer thickness, in a similar tray design. But with regards to the pressure reduction from initial pressure to the final pressure, single spacer thickness showed adequate reduction in pressure in this tray design.

- The pressure recorded with VPS group with double spacer thickness were lower than those recorded with Polyether group of both the spacer thickness in a similar tray design.
- The vent hole in the crest region provided a significant reduction in pressure during secondary impression, for both the spacer thicknesses, in a similar tray design, for both VPS and Polyether group.

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ANNEXURE I

READINGS FOR EACH GROUP

Group I A: VPS with single spacer thickness group

		F1 (Right)[Mpa]	F2 (Left) [Mpa]	F3 (Palate) [Mpa]
1]	Initial set	2.84	2.35	1.87
	Final set	2.07	1.76	1.13
2]	Initial set	2.73	2.32	1.85
	Final set	1.92	1.65	1.18
3]	Initial set	2.97	2.56	1.80
	Final set	2.11	1.71	1.09
4]	Initial set	2.84	2.56	1.90
	Final set	2.03	1.75	1.23
5]	Initial set	2.95	2.43	1.82
	Final set	2.17	1.58	1.20
6]	Initial set	2.38	2.66	1.51
	Final set	1.73	2.17	1.13
7]	Initial set	2.57	2.86	1.58
	Final set	1.94	2.39	1.10
8]	Initial set	2.38	2.44	1.30
	Final set	1.67	2.09	1.07
9]	Initial set	2.18	2.74	1.10
	Final set	1.49	2.33	0.89
10]	Initial set	2.31	2.75	1.82
	Final set	1.74	1.98	1.25

Group I B: VPS with Double spacer thickness group

		F1 (Right) [Mpa]	F2 (Left) [Mpa]	F3 (Palate) [Mpa]
1]	Initial set	2.66	2.24	0.70
	Final set	2.14	0.92	0.30
2]	Initial set	2.69	2.35	0.60
	Final set	2.27	0.98	0.25
3]	Initial set	2.87	2.56	0.92
	Final set	2.35	1.02	0.37
4]	Initial set	2.82	2.59	0.86
	Final set	2.39	1.04	0.20
5]	Initial set	2.53	2.31	0.60
	Final set	1.98	1.02	0.18
6]	Initial set	1.65	1.83	1.30
	Final set	0.02	1.07	0.80
7]	Initial set	1.72	2.34	1.10
	Final set	0.43	2.04	1.01
8]	Initial set	1.74	2.25	1.00
	Final set	0.12	1.95	0.50
9]	Initial set	1.52	2.11	0.63
	Final set	0.60	1.94	0.50
10]	Initial set	1.36	1.86	0.92
	Final set	0.25	1.52	0.13

Group II A: Polyether material with single spacer thickness group

		F1 (Right) [Mpa]	F2 (Left) [Mpa]	F3 (Palate) [Mpa]
1]	Initial set	3.45	3.08	2.60
	Final set	2.90	2.75	2.30
2]	Initial set	4.40	4.25	2.30
	Final set	3.94	3.78	2.15
3]	Initial set	2.89	2.33	2.05
	Final set	2.70	2.12	2.01
4]	Initial set	3.14	2.96	2.07
	Final set	2.95	2.76	2.05
5]	Initial set	2.98	2.70	2.03
	Final set	2.76	2.49	2.01
6]	Initial set	2.56	2.97	2.03
	Final set	2.32	2.67	2.00
7]	Initial set	2.45	2.88	2.10
	Final set	1.98	2.60	2.08
8]	Initial set	3.11	3.48	2.20
	Final set	2.76	3.11	2.16
9]	Initial set	2.52	3.48	2.20
	Final set	2.15	2.31	2.03
10]	Initial set	2.84	3.11	2.05
	Final set	2.14	2.71	2.03

Group II B: Polyether material with double spacer thickness group

		F1 (Right) [Mpa]	F2 (Left) [Mpa]	F3 (Palate) [Mpa]
1]	Initial set	2.72	2.15	1.40
	Final set	2.57	1.47	1.36
2]	Initial set	2.31	1.89	1.74
	Final set	2.06	0.80	1.61
3]	Initial set	3.43	2.60	1.72
	Final set	2.92	2.05	1.60
4]	Initial set	2.62	2.33	1.65
	Final set	2.32	2.01	1.63
5]	Initial set	3.08	2.92	1.62
	Final set	2.76	2.44	1.59
6]	Initial set	2.13	2.36	1.80
	Final set	1.20	1.82	1.74
7]	Initial set	2.26	3.57	1.72
	Final set	1.11	3.17	1.67
8]	Initial set	2.20	2.57	1.70
	Final set	1.88	2.19	1.68
9]	Initial set	2.45	2.65	1.20
	Final set	1.79	2.33	1.16
10]	Initial set	1.70	2.27	1.10
	Final set	1.27	1.72	0.90

Note: For all the groups, the samples from 1 to 5, the vent hole is placed on the left crest region and from 6 to 10 samples the vent holes were placed on the right crest region.

Annexure II

Group statistics for comparison of difference in initial and final pressure exerted in f1, f2 and f3 region for both the spacer thicknesses of VPS and Polyether group.

	N	Mean	Std. Deviation
ssf1_in	10	2.615	0.28818
ssf2_in	10	2.567	0.18288
ssf3_in	10	1.655	0.27496
ssf1_f	10	1.887	0.22076
ssf2_f	10	1.941	0.29187
ssf3_f	10	1.389	0.33271
dsf1_in	10	2.156	0.60434
dsf2_in	10	2.244	0.25413
dsf3_in	10	0.863	0.23372
dsf1_f	10	1.255	1.04134
dsf2_f	10	1.350	0.46275
dsf3_f	10	0.424	0.28695
spf1_in	10	3.034	0.57225
spf2_in	10	3.124	0.52109
spf3_in	10	2.163	0.17827
spf1_f	10	2.660	0.56864
spf2_f	10	2.730	0.45646
spf3_f	10	2.082	0.09531
dpf1_in	10	2.679	0.40204
dpf2_in	10	2.066	0.59846
dpf3_in	10	1.592	0.12246
dpf1_f	10	1.988	0.64266
dpf2_f	10	2.000	0.65714
dpf3_f	10	1.494	0.18330

Statistical analysis for comparison of difference in initial and final pressure exerted in f1, f2 and f3 region for both the spacer thicknesses of VPS and Polyether group.

		F	Sig.
ss_in	Between Groups within groups total	0.154	0.858
ss_f	Between Groups within groups total	11.357	**0.000**
ds_in	Between Groups within groups total	37.02	**0.000**
ds_f	Between Groups within groups total	5.638	**0.009**
sp_in	Between Groups within groups total	13.398	**0.000**
sp_f	Between Groups within groups total	7.016	**0.004**
dp_in	Between Groups within groups total	16.661	**0.000**
dp_f	Between Groups within groups total	2.786	0.079

Tukey’s Post hoc test for Comparison of pressure exerted in f1,f2 and f3region for both the spacer thicknesses of VPS group and Polyether group

Dependent Variable	(I) VAR00007	(J) VAR00007	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
ss_f	1	2	0.906	-0.3706	0.2626
		3	0.002	0.1814	0.8146
	2	1	0.906	-0.2626	0.3706
		3	0.001	0.2354	0.8686
	3	1	**0.002**	-0.8146	-0.1814
		2	**0.001**	-0.8686	-0.2354
ds_in	1	2	0.877	-0.5336	0.3576
		3	0.000	0.8474	1.7386
	2	1	0.877	-0.3576	0.5336
		3	0.000	0.9354	1.8266
	3	1	**0.000**	-1.7386	-0.8474
		2	**0.000**	-1.8266	-0.9354
ds_f	1	2	0.947	-0.8473	0.6573
		3	0.028	0.0787	1.5833
	2	1	0.947	-0.6573	0.8473
		3	0.014	0.1737	1.6783
	3	1	**0.028**	-1.5833	-0.0787
		2	**0.014**	-1.6783	-0.1737
sp_in	1	2	0.900	-0.5984	0.4184
		3	0.001	0.3626	1.3794
	2	1	0.900	-0.4184	0.5984
		3	0.000	0.4526	1.4694
	3	1	**0.001**	-1.3794	-0.3626
		2	**0.000**	-1.4694	-0.4526
sp_f	1	2	0.928	-0.5408	0.4008
		3	0.014	0.1072	1.0488
	2	1	0.928	-0.4008	0.5408
		3	0.006	0.1772	1.1188
	3	1	**0.014**	-1.0488	-0.1072
		2	**0.006**	-1.1188	-0.1772
dp_in	1	2	0.008	0.1448	1.0812
		3	0.000	0.6188	1.5552
	2	1	0.008	-1.0812	-0.1448
		3	0.047	0.0058	0.9422
	3	1	**0.000**	-1.5552	-0.6188
		2	**0.047**	-0.9422	-0.0058

ANNEXURE III

Group statistics and statistical analysis for comparison of pressure exerted from initial to final pressure for single and double spacer thickness of VPS group

Group statistics for single spacer thickness of VPS group

gr		N	Mean	Std. Deviation	Std. Error Mean
ssf1if	1	10	2.615	0.28818	0.09113
	2	10	1.887	0.22076	0.06981
ssf2if	1	10	2.567	0.18288	0.05783
	2	10	1.941	0.29187	0.0923
ssf3if	1	10	1.655	0.27496	0.08695
	2	10	1.389	0.33271	0.10521

Statistical analysis for single spacer thickness of VPS group

		t	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
ssf1if	1	6.342	**0.000**	0.1148	0.48682	0.96918
	2	6.342	**0.000**	0.1148	0.48564	0.97036
ssf2if	1	5.747	**0.000**	0.10892	0.39717	0.85483
	2	5.747	**0.000**	0.10892	0.39401	0.85799
ssf3if	1	1.949	0.067	0.13649	-0.02076	0.55276
	2	1.949	0.068	0.13649	-0.02149	0.55349

Group statistics for double spacer thickness of VPS group

gr		N	Mean	Std. Deviation	Std. Error Mean
dsf1if	1	10	2.156	0.60434	0.19111
	2	10	1.255	1.04134	0.3293
dsf2if	1	10	2.244	0.25413	0.08036
	2	10	1.35	0.46275	0.14633
dsf3if	1	10	0.863	0.23372	0.07391
	2	10	0.424	0.28695	0.09074

Statistical analysis for double spacer thickness of VPS group

		t	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
dsf1if	1	2.366	**0.029**	0.38074	0.1011	1.7009
	2	2.366	**0.032**	0.38074	0.08675	1.71525
dsf2if	1	5.355	**0.000**	0.16695	0.54326	1.24474
	2	5.355	**0.000**	0.16695	0.53588	1.25212
dsf3if	1	3.751	**0.001**	0.11703	0.19313	0.68487
	2	3.751	**0.002**	0.11703	0.1924	0.6856

ANNEXURE IV

Group statistics and statistical analysis for comparison of pressure exerted from initial to final pressure for single and double spacer thickness of PE group

Group statistics for single spacer thickness of PE group

gr		N	Mean	Std. Deviation	Std. Error Mean
spf1if	1	10	3.034	0.57225	0.18096
	2	10	2.660	0.56864	0.17982
spf2if	1	10	3.124	0.52109	0.16478
	2	10	2.730	0.45646	0.14435
spf3if	1	10	2.163	0.17827	0.05637
	2	10	2.082	0.09531	0.03014

Statistical analysis for single spacer thickness of PE group

		t	df	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
spf1if	1	1.466	18	0.160	0.25511	-0.16197	0.90997
	2	1.466	17.999	0.160	0.25511	-0.16197	0.90997
spf2if	1	1.799	18	0.089	0.21906	-0.06624	0.85424
	2	1.799	17.693	0.089	0.21906	-0.06681	0.85481
spf3if	1	1.267	18	0.221	0.06392	-0.0533	0.2153
	2	1.267	13.757	0.226	0.06392	-0.05633	0.21833

Group statistics for double spacer thickness of PE group

gr		N	Mean	Std. Deviation	Std. Error Mean
dpf1if	1	10	2.679	0.40204	0.12713
	2	10	1.988	0.65633	0.20755
dpf2if	1	10	2.066	0.59846	0.18925
	2	10	2.000	0.62732	0.19838
dpf3if	1	10	1.592	0.12246	0.03872
	2	10	1.494	0.27097	0.08569

Statistical analysis for double spacer thickness of PE group

		t	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
dpf1if	1	2.839	**0.011**	0.24339	0.17965	1.20235
	2	2.839	**0.012**	0.24339	0.17198	1.21002
dpf2if	1	0.241	0.812	0.27417	-0.51001	0.64201
	2	0.241	0.812	0.27417	-0.5101	0.6421
dpf3if	1	1.042	0.311	0.09403	-0.09956	0.29556
	2	1.042	0.317	0.09403	-0.10593	0.30193